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Copeland, Jason C, Major, USMC

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This study reviews both the challenge of subterranean warfare and opportunities on the horizon to counter the threat. New technologies offer opportunities to address tunnels, caves, and urban subterranean defenses. However, these technologies have limitations as far as capabilities and also are not currently fielded in large enough quantities for a great power war. In the end, concept and capabilities will have to work together to address the threat. The best way to identify that mix is through fielding a test bed unit optimized for the challenge.

To prepare for a great power war in subterranean networks there needs to be a unit assigned this role as the primary developer of doctrine, organization, training, and equipping of units to confront subterranean challenges in general, the Korean threat in particular. This unit should not reside on the Korean peninsula as most units involved will be responsible to blunt the infiltration and attack efforts of the North Korean forces and will not have all the manpower required to search the vast underground facilities that have been built over the past few decades.

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Marine Corps University
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AUTHOR: Major Jason C. Copeland, USMC

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Mentor and Oral Defense Committee Member: _____
Approved: Benjamin Jordan PhD
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Oral Defense Committee Member: _____
Approved: Paul D. Golbert, PhD
Date: 30 April 18

Executive Summary

Title: Combined Arms Superiority Means an Enemy Moves Underground – A Historical and Future Look at Subterranean Forces

Author: Major Jason C. Copeland, United States Marine Corps

Thesis: The United States Armed Forces are currently not trained or equipped to counter the challenges posed in a great power conflict that are employing asymmetric tactics to subvert aviation and surface delivered fires by operating in subterranean environments.

Discussion: Since the battle of Midway, the United States has operated in an aviation permissive environment with intelligence, surveillance, and reconnaissance consistently overhead observing enemy assets. Enemy forces have understood this principle and searched for effective ways to deny the US the ability to target deliberate defenses. The enemy went underground, a phenomenon observed since the amphibious landings in Iwo Jima in World War II, again in the tunnels in Vietnam, and, more recently, in ISIS defenses in Iraq and Syria as well as North Korea's extensive tunnel network.

Other allies around the world have been seen a similar trend. For example, the Israeli Defense Force has spent the better part of the last decade countering Hamas tunnels in the Gaza Strip.

This study reviews both the challenge of subterranean warfare and opportunities on the horizon to counter the threat. New technologies offer opportunities to address tunnels, caves, and urban subterranean defenses. However, these technologies have limitations as far as capabilities and also are not currently fielded in large enough quantities for a great power war. In the end, concept and capabilities will have to work together to address the threat. The best way to identify that mix is through fielding a test bed unit optimized for the challenge.

Conclusion: To prepare for a great power war in subterranean networks there needs to be a unit assigned this role as the primary developer of doctrine, organization, training, and equipping of units to confront subterranean challenges in general, the Korean threat in particular. This unit should not reside on the Korean peninsula as most units involved will be responsible to blunt the infiltration and attack efforts of the North Korean forces and will not have all the manpower required to search the vast underground facilities that have been built over the past few decades.

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The Commandant of the Marine Corps put forth the Marine Corps Operating Concept in September of 2016 to spark an educated discussion on the future of warfare and the challenges that Marines will face. Specifically, it discussed the need to train for complex environments, many of which will be located below ground.[1] Subterranean warfare in caves, sewer systems, and man made tunnels is not a new phenomenon in military history. However, some of the painful lessons learned underground fell off of training plans that are already overloaded with tactics to counter current threats. Eventually, we will meet another determined enemy who has had years to prepare for a US military that is technologically more advanced in terms of air power and strike capabilities.

This study offers a series of historical cases the U.S. Marine Corps can use to prepare for a subterranean war. Using historical insights - combined with military theory, tactics, and operational art - we can learn from the hard lessons of those who have already fought and bled uprooting a determined and buried enemy. We can apply the lessons learned to our future training when a similar enemy arises, forcing infantrymen to dust off these techniques as well as guiding the scientists in industry in developing the capabilities required to venture below the surface.

THE IWO JIMA EXPERIENCE

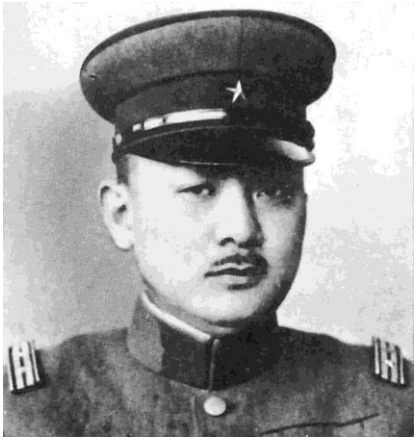
Joint Doctrine defines air superiority as "that degree of control of the air by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats."[2] The United States has operating under air and indirect fire superiority since June 3, 1942 after the Battle of Midway. The United States sunk four of the Japanese Imperial Navy heavy carriers over the course of three days ceding air superiority to the United States. According to Tom Hone this battle was a turning point in World War Two for the

execution of the campaign in the Pacific and also outlined a framework for establishing air superiority and multi-domain dominance.[3]

Air and indirect fire technology has evolved since World War Two becoming increasingly more precise and lethal. Japanese forces adapted in World War Two places their defenses underground. The same Pacific Campaign that included the Battle of Midway is also where we see some of histories first large scale subterranean operations. The historical example of Iwo Jima provides a blueprint for large-scale prepared defensive subterranean operations that will inevitably resurface in future large-scale operations.

The Marine Corps and Navy marched across the Pacific in World War II hopping islands with amphibious assaults to mainland Japan. The landings varied from unopposed landings at Guadalcanal to the bloody amphibious assault across coral reefs in Tarawa.[4] However, it was the

heavily fortified Iwo Jima Island that highlighted a truly determined adversary. Lieutenant General Tadamichi Kuribayashi, the commanding general of the Japanese defenders, knew the



tactics of the inevitable amphibious assault the Marines would lead on the pork chop shaped island. He understood that the United States must take over his airstrips protecting mainland Japan having spent several years as a junior officer in American and Canadian Embassies.[5] Kuribayashi's 21,000 troops, additional laborers, and some of the best engineers the Empire of Japan maintained constructed an elaborate defense in eight months. [6] The defenses on Iwo Jima were some of the most innovative seen by 1945. There even were reports that the Empire of Japan sought tactical advice from Nazi Germany on how to defend against American invasions.[7] This was a well thought out and prepared position that was prepared to cause as many casualties as possible from American forces.

Additionally, the technical laydown of the defense-in-depth were some of the best-laid defenses the United States faced during the Pacific Campaign. Concrete pillboxes and other defensive fortifications existed prior to the landing on Iwo Jima.[8] However, they were not intertwined as they were on the volcanic ash covered island of Iwo Jima. This "masterpiece of

impregnability" produced by Kuribayashi's men transformed natural caves, dug hundreds more, and linked them to underground fortresses 30 to 40 feet below ground. Inside each

of them the purpose was to hide coastal guns, pillboxes, and mortars from observation. Hiding them underground was to limit the ability of amphibious forces to destroy them with air or naval gunfire. General Holland M. Smith described the defenses in his book *Coral and Brass* that "beyond the first line of pillboxes, protected by mine fields and accurately placed overlapping fire from hidden guns, the island was a huge warren of holes, caves and passages in rocky ridges and cliff faces. Every day of our advance on Iwo Jima showed us another marvel of defensive construction."[9] This is high praise from General H.M. "Howling Mad" Smith who commanded the landing forces during the battle.

Moreover, the genius of the defenses is the center of gravity analysis by Lieutenant General Kuribayashi on the invading American forces. He knew the seaborne forces would use an overwhelming amount of naval and aerial ordnance to support the landing forces.. General Howlin' Mad Smith's intelligence officer estimated Iwo Jima defenses were only strengthened after the Seventh Air Force conducted "extensive air bombardments of Iwo Jima causing the underground positions to be made more elaborate than they might otherwise have been."[10] The power of direct fire from ships, indirect fire, and close air support is clearly the center of gravity (COG) of the United States invading forces in World War Two and was correctly identified by the defenders at Iwo Jima. General Kuribayashi transmitted back to mainland Japan his assessment of his defensive preparation in "however firm and stout pillboxes you may build at the beach, they will be destroyed by bombardment of main armament of the battleships. Power of the American warships and aircraft makes every landing operation possible to whatever beachhead they like."[11]

Additionally, to counter the center of gravity one must attack the critical vulnerability. According the Marine Corps Doctrinal Publication -1 *Warfighting* "we should focus our efforts

against a *critical vulnerability*, a vulnerability that, if exploited, will do the most significant damage to the enemy's ability to resist us."[12] The critical vulnerability in this case is the ability to find, fix, target, and neutralize the defending forces. By going underground and building the defense in depth, the Japanese defenders denied fire superiority to the Marines struggling to wrestle the island away. This was by design from Kuribayashi in explicit instructions to his troops. One Japanese soldier transcribed one of his "Essential Battle Instructions" prior to the February 19 landing that "while the enemy bombardment is going on, we must take cover in the dugouts and we must keep our casualties at a minimum."[13] Large concentrations of exposed troops, pillboxes, or other defensive structures were avoided to reduce the ability of the US forces to target them.

Additionally the Japanese employed other defensive techniques to counter the United States center of gravity: air and fire superiority. Once the Marines are ashore, as Admiral Chester Nimitz, Commander in Chief of the Pacific later observed, "the proximity of our troops to enemy positions frequently denied us the benefit of adequate naval bombardment, air bombing, or shore artillery support."[14] Not only intertwining defenses but also close fighting of forces on both sides restricted the ability of the release of munitions.

Finally, the Japanese on Iwo Jima provided a historical blueprint on how to counter United States direct, indirect, and air superiority by going to ground. Operating in man made or reinforced caves in an interconnected subterranean environment effectively countered the United States center of gravity. The subterranean defenses in depth forced in an intense infantry struggle to root the Japanese out of their intertwined caves and tunnels resulting in 21,558 casualties of whom 5,521 were killed or died of wounds.[15] Admiral Kelly Turner, the commander of the amphibious task force on Iwo Jima, was correct in asserting that the defenses

there were “tremendously better organized and more effective” than anything previously encountered in the Pacific, and that “Iwo Jima is as well defended as any fixed position that exists in the world today.”[16] This defensive blueprint of a brilliant commander in Lieutenant General Tadamichi Kuribayashi was expressed perfectly by one Marine, after the struggle for the island was over: “Let’s hope the Japs don't have any more like him.”[17] While there may not be a commander like him or an appetite for an amphibious assault to that scale ever committed again the blueprint of “going to ground” and making Marines give their “last penny in terms of time, lives, and equipment, before seizing Iwo Jima.”[18] As Iwo Jima demonstrates, operating in subterranean structures is not a new phenomenon. This historical case study provides foundational insights into how adversaries counter air and fire superiority through using complex terrain, a time-tested tactic on display in other crucial cases like Vietnam.

THE TUNNELS OF CU CHI

The Viet Cong Military Region 4 of the “notorious ‘Ho Bo Woods’ region” in the Iron Triangle, north east of the town of Cu Chi bravely fought in a vast tunnel system shielding them from the overwhelming firepower asymmetric advantage enjoyed by the Military Assistance Command of Vietnam (MACV).[19] A captured communist tunnel construction manual assessed the US forces as “several times superior to us in strength and modern weapons, but he will not chase us from the battlefield, because we will launch surprise attacks from within the underground tunnels.”[20] We can take valuable lessons learned written in blood to inform conversations we can glean from is the manning, training, and equipment the “Tunnel Rats” to inform future formations of modern “Tunnel Rats” to counter a determined enemy in the defense when that future conflict arises.

First, we need to look at the enemy inhabiting the Ho Bo Woods, which began years before the actual intervention of MACV Forces in Vietnam in 1965. In the 1940s and 1950s during the French Indochina War the tunnels of Cu Chi were already hand dug by the Viet Minh Forces, the anti colonial guerrillas opposing the colonial French powers.[21] The tunnels stretched roughly 20 kilometers in 1950 according to interviews from survivors of the Vietnam War in a Mickey Grant documentary film.[22] When US Forces entered to war with the B-52 and artillery strikes all the local forces reopened the tunnel networks and just "kept digging".[23] Vietcong Major Nguyen Quot "estimated the digging operations had grown to close to two hundred kilometers by the time the American army arrived in 1965."[24] The enemy viewed the tunnels as a way to offset the United States bombing capabilities and require ground forces to search them out in the jungles and tunnels of this complex terrain. This was the war the Viet Cong forces preferred to fight, grabbing the Americans by the belt and negating the overwhelming aviation and surface firepower advantages American units relied upon.

Additionally, even bringing the US forces in close to negate American firepower in the tunnel system did not fully provide the strategic advantage sought by Viet Cong. Engagements were well inside even the maximum effective range of the direct fire weapons carried by the average soldier in the area. The VC in the Ho Bo Woods set up mine fields, small three to four soldier teams, and used sniper fire tactics from firing ports in the tunnels to slowly attrite the forces

Lieutenant Colonel George Eyster, commander of the "Black Lions" Battalion of the U.S. 1st Infantry Division, lies mortally wounded after being hit by a sniper during Operation Crimp, the first full-scale operation in Cu Chi district in 1966. His dying words were: "Before I go, I'd like to talk to the guy who controls those incredible men in the tunnels."

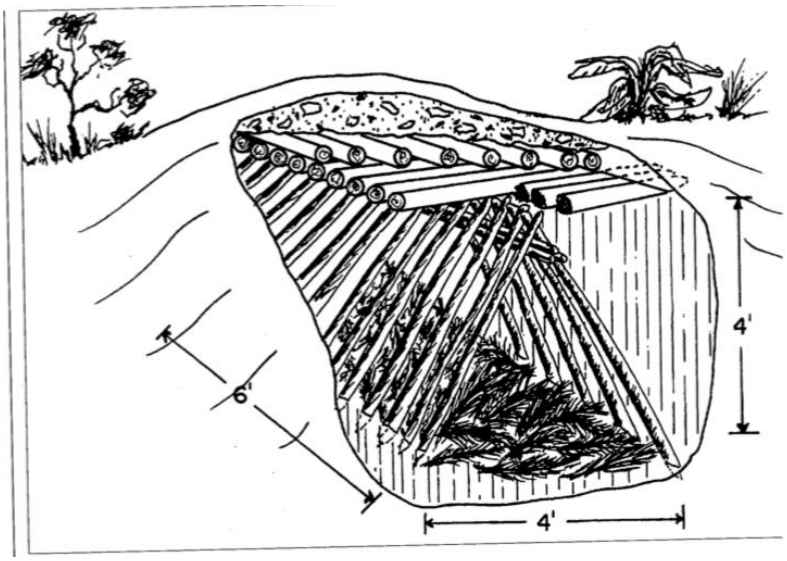
according to VC Lieutenant Nguyen Thanh Linh.[25] On 12 January 1966 in the opening moments of Operation BUCKSKIN Lieutenant Colonel George Eyster, Jr. was mortally wounded.[26] [27]This not only provided a limit on US firepower but it also had a psychological effect on the average infantryman who struggled to find, fix, and finish an enemy only exposing himself for brief moments.

Lastly, with regards to the Viet Cong forces in the tunnels of Cu Chi, these were not temporary fighters that were occupied only the defense of the area, but structures that were inhabited for the duration of the conflict. Males dominated the operations in the tunnels but there also were women and elderly people. A female Viet Cong soldier who was married to a member of her fighting team even delivered a baby underground with the Americans in the attack.[28] There were even performers who travelled and filmed performances in the Cu Chi tunnels during the war to raise moral and the fighting spirit of the individual soldiers who spent days, weeks, and sometimes months living by candlelight.[29] This enemy truly was determined not only to survive, but also last the attackers who flew above, bombed the land, and occasionally massed for large operations.

The tunnels Vietnam, similar to those at Cu Chi, were not haphazard structures designed to simply live in or survive in. They were interconnected and reinforced systems that were also defensively well though out. A ten-page technical and political instruction manual issued by the communist forces was recovered on 28 September 1967 and translated by the Defense Intelligence Agency provided a basic blueprint for VC forces. These instructions gave tactical and strategic recommendations for continuing to build and reinforce the system even in the presence of the US forces.[30] The 8-12 January 1966 Operation CRIMP after action reports from the 173d Airborne Brigade described the tunnels as the “most extensive and intricate one the

Brigade has encountered. It included mutually supporting trenches, and bunkers, and a maze of multi-level tunnels, some of which were constructed of steel and concrete."[31]

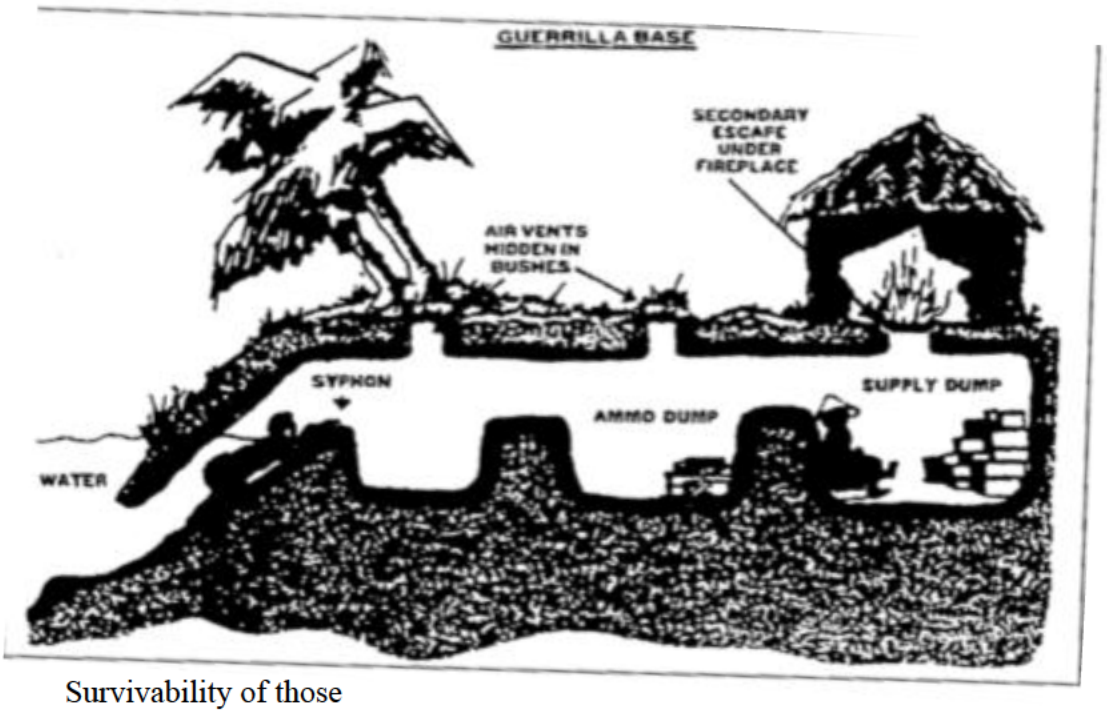
Also, the interconnected fortifications were not primitive even though they were built by hand. The labyrinth of tunnels included steel overhead beams, concrete, and A-Frame reinforcements designed to withstand US strategic bombing reducing a perceived asymmetric advantage by the MACV in superior fire support.



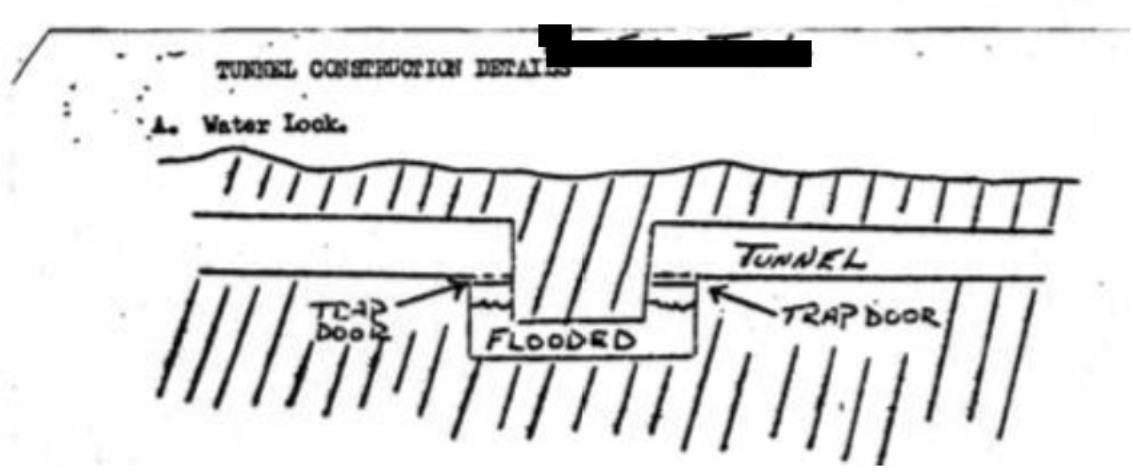
[32] The reinforcements would not only limit the effectiveness of aviation and surface delivered fires, but also withstand most attempts to destroy them with high explosives or be repaired with little effort once US forces "cleared" the area and moved back to the larger bases.

Additionally, the tunnel structures expanded the ability to sustain large VC formations over long periods of time. Ventilation shafts to give fresh air jutted out at strategic junctures angling away from rainwater run off flow to not flood the tunnels during rainstorms, even to the east to catch the warm morning air to relieve some of the cold and dampness of the maze underground.[33] Underground wells did not extend to the surface providing drinking and cooking water increasing the survivability underground.[34] There were even hospitals similar to those subterranean fortifications on the Island of Iwo Jima, complete with operating rooms with walls lined with recovered US parachutes to reduce infections to wounded soldiers.[35]

Two Viet Cong nurses prepare for an operation inside a tunnel hospital. The medical equipment was mostly American bought on Saigon's black market. Parachute nylon hangs on the walls of the hospital to keep earth and infection away.



Survivability of those soldiers increased with the multiple trap doors offering primary, alternate, and supplemental options for entrance and escape. Some of the entrances even began below water level on river banks, inside



village hamlets, pig pens, ant hills, or many other well camouflage places that US soldiers were unwilling to go into or unable to find.[36] The Vietnamese people were also smaller in general and did not wear bulky gear like their large American counterparts, so the entrances and tunnels did not have to be enormous. Deep inside the tunnels the corridors rarely were tall enough for a single soldier to pass through other than crawling on your stomach. After the initial tunnel

entrance construction included random turns to limit gunfire from advancing attackers. The random turns also made deducing the direction of the tunnels impossible to predict from the surface. These random turns also included water locks, which required attackers to submerge to find the connecting passageway or also to limit how far smoke would travel in the tunnels.[37]

Moreover, the most impressive part of the tunnel systems in Cu Chi was the extreme variety of dangers posed to attackers who entered the tunnels. Throughout the Iron Triangle there often were trap doors leading to levels under ground that were expertly camouflaged into the floor with wire loops on trap doors to open them. Many of the trap doors included booby trapped with grenades or other recovered and repurposed American explosives. If the grenade booby traps did not deter the attacker, false floors with sharpened bamboo punji sticks pits were waiting to maim a tunnel explorer.[38] A wounded soldier required other soldiers to pull him out which is a painstaking process in such tight quarters.

Additionally, one of the most effective amplification of natural fears of most humans was operationalizing of insects and other animals other than the rates that naturally reside in dark, damp, and deep subterranean spaces. The VC trained hornet nests and strategically placed them at tunnel entrances and booby-trapped them with trip wires to agitate the attackers. The defenders buried beehives coupled with mines to set off explosives and angry bee swarms over

the attackers. Trip wires unleashed boxes of spiders, scorpions, or fire ants when an unsuspecting soldier explored the dark and damp spaces.

The insects were all possible agitations that in most cases did not prove fatal. However, the Viet Cong would set traps with snakes, particular the bamboo viper that is extremely poisonous. Lieutenant Jack Flowers recalled "the Vietnamese somehow tied the viper into a piece of bamboo with a piece of string and as the tunnel rat goes through he knocks it, and the snakes come out and bines you in the neck or the face and the blood gets to your hear very quickly."[39] The danger of exploring enemy occupied territory below ground proved hazardous not only from grenades, make shift explosives, or other man-made tools of destruction, but also from insects and animals native to the Ho Bo Woods.

The MACV forces in Vietnam knew the tunnel networks existed and designed large-scale operations to counter them. The leadership did not fully understand the tunnel complexity of design, the capabilities of the defenders enjoyed in them, or the force required to dislodge the Viet Cong from their underground bases. The MACV forces in Corps Zone III did try seemingly primitive methods of gas, fire, and explosives to remove the Viet Cong from the tunnel systems that are not knew to warfare. However, the tunnels of Cu Chi is one of the first historical instances where enemy forces had created a network so complex to withstand the effects of all three to include aviation and surface delivered fires. The enormity of the task to destroy the VC headquarters within striking distance of Saigon, forced the commitment of soldiers, "tunnel rats" to search the underground labyrinth.

In 1966 the Army 1st Infantry Division committed two US regiments to Operation CRIMP from 8-12 January to "drive into the Ho Bo Woods region to destroy the headquarters of Military Region 4."[40] The concept of operations included a heliborne assault in a hammer and

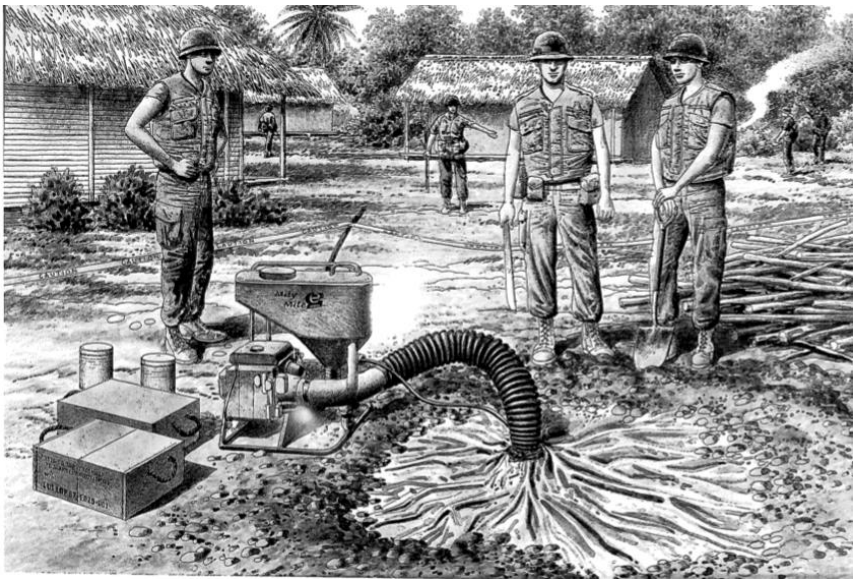
anvil movement. The "anvil" of the 1st Royal Australian Regiment (1/RAR) set up blocking positions along the Saigon River while the 173d Airborne Brigade drove the VC out of hiding where they would be destroyed.[41] The 3d Brigade would also air assault into the southwest of the Ho Bo Woods and clear with armored personnel carriers and armor support. No plan survives first contact and through faulty intelligence, the 1/RAR "anvil" blocking force actually inserted via helicopter fortuitously on top of the VC headquarters. According to the 173d Brigade After Action Report detailing 1/RAR actions, the Aussies discovered "intricate multi-level tunnel systems were discovered during the day containing several large weapons caches and numerous documents which proved beyond a doubt that the 1/RAR was sitting on top of the VC Political Headquarters of the Military Region 4…indicating that the entire headquarters was located within the Bde AO."[42] The blocking "anvil" force became the default tunnel search force.

The leadership in Operation CRIMP, certain to find trenches, fortified fighting positions, and tunnel complexes, prepared to force VC out and deny future access to the tunnel structures. Australian and US soldiers reluctantly began searching the tunnels with a combination of new and old techniques. Flamethrowers, man portable and mounted on tanks, were a primary weapon for caves and tunnel structures in the Pacific Campaign in WWII. However, in the jungles of Vietnam, with little access to roads and resupply outside of heliborne assets, the M2A1-7 portable flamethrower "were little used in Vietnam owing to their 70lb weight when full, and the fact that they were expended in seconds."[43] Fire did not 'smoke them out' the flamethrower did however extinguish a vital resource for holed up enemy in tunnel complexes, oxygen.

Also, high explosives proved ineffective as a method of destroying the tunnels. B-52 strikes with large bombs produced large craters, but without pinpoint accuracy to guide the pre assault bombing campaign onto a man sized tunnel route, they were ineffective to support

ground troops. The bombing campaigns did notify the Viet Cong forces that once the shelling stopped, the US forces would not be far behind as they usually are.[44]

Another way to combat the oxygen supply to the enemy was to pump in riot control agents, CS grenades or bulk powder, into the tunnel complex. After widening the tunnel opening the well-camouflaged entrance with explosives, the infantry troops would call for the Mity Mite blower. The M106 Mity Mite was initially a commercial off the shelf industrial blower used to spread pesticides on crops and was made by Sears and Roebuck.[45] 10 pounds of riot control powered CS pumped through the Mighty Mite would "drive out and in some cases asphyxiate inhabitants, as it displaced oxygen."[46] The chemical troops located at the brigade and division level that operated the Mity Mite would pump fresh air to clear the tunnels of CS.[47] Clearing the CS gas out of the tunnels was an inexact science and a lesson learned the hard way. Corporal Bob Bowtell of the Australian Royal Engineers died after he entered a trap door, became stuck, lost consciousness due to CS and smoke inhalation, and could not be retrieved in time from the tunnels.[48] Ironically, the Joint Chiefs of Staff approved the use of CS gas in Vietnam on November 3, 1965 and Operation CRIMP was one of the first uses of the riot control agent, and attributed to a friendly casualty in combat actions.[49] The Mity Mite in operation still needed refining to effectively search tunnels.



Even though the first use of the Mity Mite was by the ARVN 8th Infantry Regiment, 5th Infantry Division in October of 1965, it was not portable enough for pervasive implementation within all the infantry units, even at the battalion level. The demand for the Mighty Mites was too high, and the tunnel network to vast, to effectively support three regiments in Operation CRIMP. The Army even tried to substitute a mobile version of the Mighty Mite and landed Huey helicopters near the tunnel entrances equipped with an air compressor hose. The Huey pumped CS, smoke, and eventually clean air into the tunnel systems if there was no Mity Mite and chemical platoon members available, at great risk to the aircraft and crews.[50] A technological solution was not the simple answer when it comes down to tunnel warfare in Vietnam.

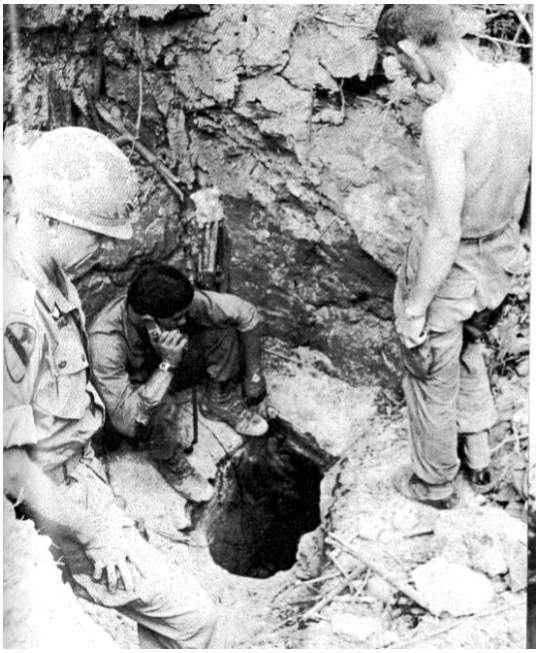
Unfortunately, the lack of a technological advantage or solution relegated the task of tunnel exploration to individual soldiers. Trying to find the enemy in a jungle is difficult enough without adding dark, damp, and confined quarters to the other VC use of snakes, sharpened sticks, booby traps, and ambushes to keep the attacking soldiers out. Service dogs, adept at sniffing out and identifying entrances to tunnels based on distinct human smells, could not be induced to actually enter the tunnels.[51] The scout dog detachment, similar to the Mighty Mite, resided at the brigade level. However, the Army again turned to industry and developed another enemy detection system in the XM3 airborne olfactonic

personnel detector or "people sniffer." [52] The XM3 capability was not widely used or known about in operations within Vietnam since it was only marginally effective to searching and clearing tunnel systems. The system was bulky and also mounted on a Huey aircraft, which was not always able to land close the tunnel entrances.

Additionally, physical and psychological forces kept US and ARVN soldiers out of tunnel system. American GI's were larger in general than the Vietnamese and made crawling through trap doors in tight spaces difficult.[53] Also, like the service dogs above, you could not force a tunnel rat into service expecting outstanding results. Claustrophobia and the dangers that lurked around every corner, floor, ceiling, and wall were sometimes trumped by the fear of being buried alive. This required not only a Soldier with a smaller physical stature but also a volunteer trained, equipped, and employed for tunnel exploration.

Soon after the completion of Operation CRIMP, training of tunnel exploration personnel became a 25th Infantry Division priority and subsequently a task to develop methods and professional personnel belonged to the 9th Chemical Detachment under Captain Herbert Thornton. The brave and men of smaller stature originally called themselves "tunnel runners."[54] Thornton would only take volunteers as tunnel rats since if "you ordered a man into a tunnel, he would come straight out and say it was only ten or twelve feet long even if it was much

longer."[55] This division priority, with the pervasive use of tunnels and subterranean fortifications late in 1966, transferred to 1st Engineer Battalion of 1st Infantry Division of the Big Red One.[56] The shift of mission away from the Mighty Mite and the Chemical Detachments was so soldiers with demolitions expertise would be used as tunnels rats in case a commander decided to try to destroy the tunnel. The high explosives to collapse the tunnel and deny the enemy the ability to use it again as a form of terrain ultimately proved futile. The VC simply rebuilt them.[57]

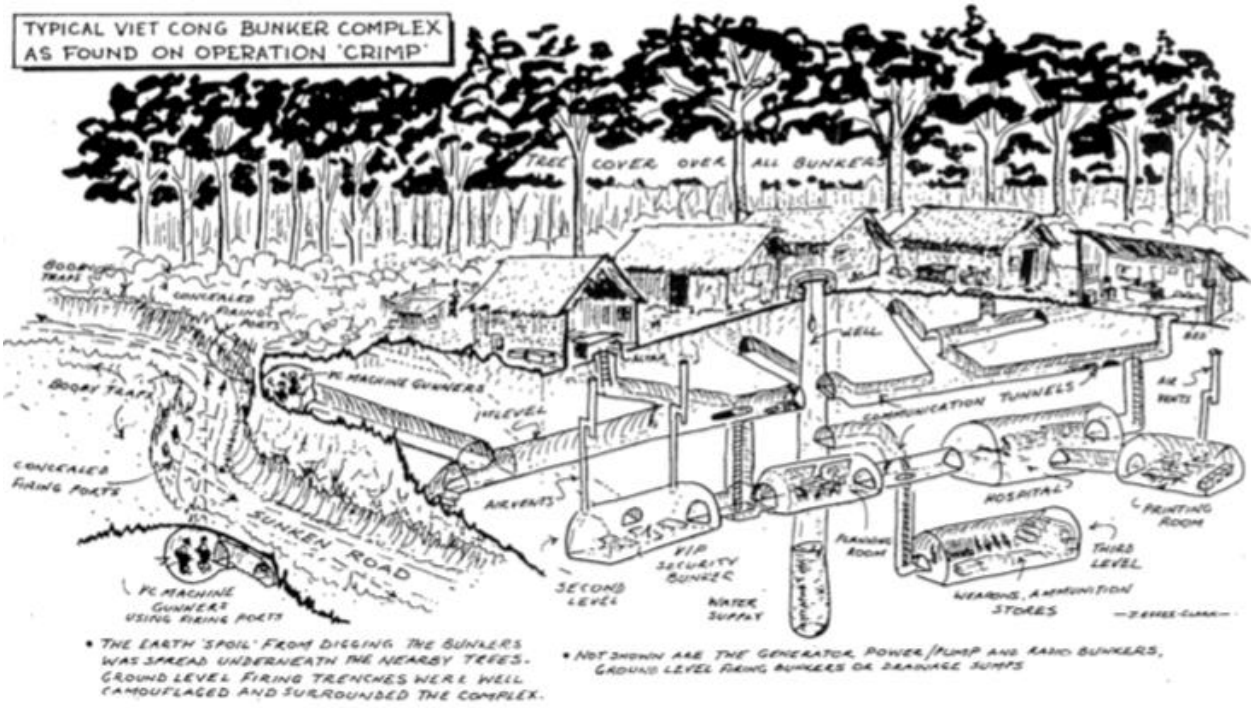


Finally, the equipment used in tunnel exploration was usually different and highly personal for each tunnel rat. However, most often it included a flashlight, fighting knife, a field phone, and a pistol as wielding a rifle in a confined space was too cumbersome to a tunnel rat searching through enemy territory while crawling on your abdomen. The pistol was most often with earplugs since the sound was deafening in the tunnels. The fighting knife was seldom used in hand-to-hand combat, but often used as a tool to search for trap doors and booby traps. The field phone served two purposes; communication to the surface and as a method to measure how far the tunnel extended by counting the amount of line unspooled. The primitive tunneling equipment was not as technically savvy as the aircraft and fire support flying above ground, but was arguably more effective in a subterranean environment fight.

The Vietnam tunnel complexes produced many lessons learned that are valuable to future subterranean fights. In the Commanders Combat Note 91 on 22 January 1966 after the termination of Operation CRIMP, the Commanding Officer of the 173d Airborne Brigade Brigadier General Williamson noted as the first lesson learned that "clearing bunkers and tunnels is slow and deliberate procedure which can be costly in terms of casualties. All means available, such as tear gas, flame throwers, smoke and demolitions must be employed in order to keep friendly casualties to the minimum."[58] This does not abdicate the unit from searching the tunnels and simply destroying them or denying their use by the enemy with CS gas.

The tunnels proved to be reconstituted by the enemy and used again in future attacks, necessitating a requirement for future forces to prepare to search and even occupy the tunnels. The Combat After Action Report submitted by the 173d Brigade on 23 February 1966 touted the success of Operation CRIMP and the search of tunnels yielded over 100,000 pages of captured intelligence including individual diary entries, lists of communist party members in Saigon, transistor radios, large stores of rice, and numerous types and models of weapons.[59] BGen Williamson also noted in his commanders note that "the capture of the enemy documents during this operation possibly hurt the enemy more from a long range view point than did the loss of his personnel and weapons."[60]

Lastly, the Viet Cong knew they could not fully match or counter the fire support capabilities of the MACV and developed an asymmetric advantage underground.


TYPICAL VIET CONG BUNKER COMPLEX
AS FOUND ON OPERATION 'CRIMP'
TREE COVER OVER ALL BUNKERS
BOOBY TRAPS
CONCEALED FIRING POINTS
PC MACHINE GUNNERS
2 LEVEL
BOOBY TRAPS
CONCEALED FIRING POINTS
SUNKEN ROAD
PC MACHINE GUNNERS USING FIRING POINTS
AIR VENTS
SECOND LEVEL
VIP SECURITY BUNKER
WATER SUPPLY
HELL
COMMUNICATION TUNNELS
AIR VENTS
HOSPITAL
PRINTING ROOM
PLANNING ROOM
THIRD LEVEL
WEAPONS & AMMUNITION STORES
* THE EARTH 'SPOIL' FROM DIGGING THE BUNKERS WAS SPREAD UNDERNEATH THE NEARBY TREES. GROUND LEVEL FIRING TRENCHES WERE WELL CAMOUFLAGED AND SURROUNDED THE COMPLEX.
* NOT SHOWN ARE THE GENERATOR, POWER/PUMP AND RADIO BUNKERS, GROUND LEVEL FIRING BUNKERS OR DRAINAGE SUMPS

Building elaborate subterranean systems that could withstand any munitions short of a direct hit on one of the tunnel entrances; will most likely be a tactic that future formations and operations will encounter.[61] However, we must not be caught unprepared when the valuable lessons of Operation CRIMP, the tunnels of Cu Chi, and the Tunnel Rats of Vietnam are hear to guide our future subterranean operations.

CURRENT FIGHTS AND FUTURE SUBTERRANEAN WARFARE TECHNOLOGIES

The future of warfare is likely going to be more complex due to urbanization, increased competition for resources, and the diffusion of technology. Yet, as The Marine Corps Operating Concept remind all leaders "no level of automation or use of robotics will replace the fact that war will always center on violence directed by humans against other humans."[62] Even the most battle-hardened warrior appreciates a technological or cognitive advantage. There are technologies available that will assist the future "Tunnel Rat" who ventures into a heavily defended maze of dark and deadly corridors. Emerging technologies have been used to target

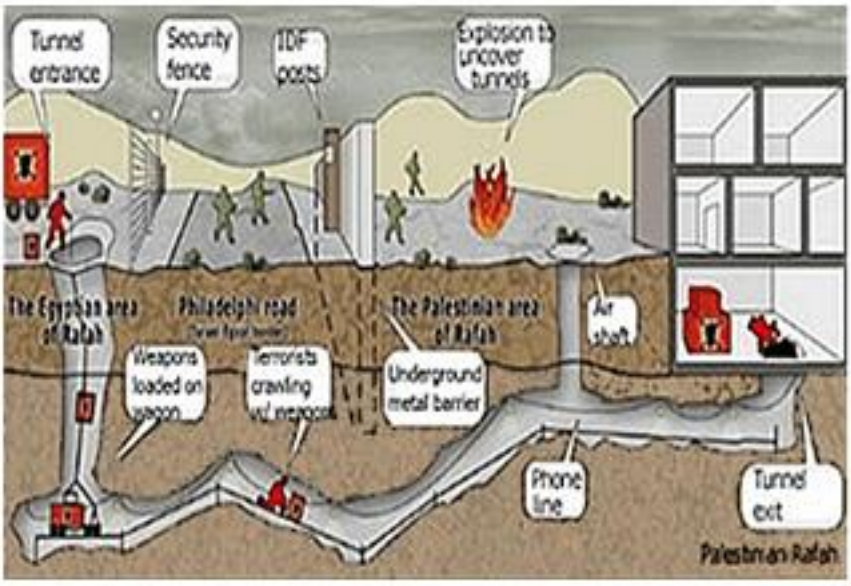
tunnels in urban fights against the Islamic State of Iraq and Syria (ISIS) as well as military applications in Israel to find infiltration tunnels into the Gaza Strip. These current operations provide examples of the need for emerging technology and training required on a small scale.

However, the larger organizational question is where do these technologies fit in the organization for a great power war with an entrenched enemy such as North Korea. The subterranean defenses have driven the Defense Advanced Research Projects Agency (DARPA) to search for military technological applications however; the integration has not been fully explored or trained too by military professionals. The answer cannot be to simply dump another "capability" for a unique application on the squad leader like much of the weight of technologies already saddling their shoulders. The larger debate needs to be structured around not only the purpose of the technology and the origins from which it was derived, but ultimately the role that we need this to play in the "race to Pyongyang" which will be similarly organized as the "race to Baghdad."

First, lets look how some of the offensive and defensive networks have been used against

United States and Coalition forces in recent conflicts, most notably ISIS forces. According to U.S. Central Command press releases on Feb. 6 in Syria near Abu Kamal, coalition military forces conducted air strikes destroying two ISIS supply routes and a tunnel entrance amongst other targets. On the same day in Iraq near the Hamrin Mountains two strikes destroyed 20 ISIS tunnels.[63] These strikes are against a violent extremist group that has been in conflict against US

firepower for the better part of almost two decades in Iraq and knows the US capabilities well. An already challenging environment to target fighters amongst a neutral and non-uniformed force has become exponentially more complicated with the integration of tunnel networks amongst heavily urban areas. The ISIS defenses have shown some upgrades to simple entrenching by hand as in Vietnam with large digging machines. However, the techniques to counter the tunnel systems revert back to the easy terrain denial answer in the form of blowing them in place, a technique that did not prove to be sufficient in the Vietnam example.



A Gaza Strip-Egypt

Smuggling Tunnel Illustration

Source: IDF

For a better look at the urban tunnel structures we can turn to the Gaza Strip and the Israeli Defense Force (IDF) who have detected and destroyed many tunnel networks used to launch attacks into Israel. The Hamas tunnel networks served as launching points for raids against Israeli population and IDF troop concentrations. The 2014 Jewish Institute for National Security of America (JINSA) describes as:

> An extensive network beneath Gaza offered cover and concealment, making it extremely difficult, if not impossible, for the Israelis to detect or prevent movement of fighters, munitions and weapons. In other words, Hamas's tunnels countered Israeli aerial reconnaissance capabilities. Infiltration tunnels allowed a limited number of Hamas fighters to reach Israeli territory undetected.[64]

This study did not fall on deaf ears, but was simply lost amongst a host of other United States requirements in the surface combat around the globe. Even as late as March 18, 2018 the IDF destroyed a network of tunnels trying to reconnect to previously destroyed and denied terrain according to CNN reporters in Gaza.[65] The determined enemy has proven adaptive to the fire superiority the IDF possesses and looks to counter it in a subterranean asymmetric advantage. The JINSA study, based on the Hamas tunneling efforts, makes a bold recommendation to US strategy, policy, and budget makers that threats like Iran, North Korea, and Hezbollah have already shown extensive underground command and control networks to "leverage low-tech solutions to overcome technological advantages enjoyed by conventional militaries."[66]

Ultimately the character of the combat will dictate the role the subterranean searching technology capabilities integrate into forward units. If a leader has not purposefully studied some of the history of subterranean warfare looking to doctrine provides few answers or applications. Joint Doctrine devotes only a paragraph to subterranean discussion with no viable solutions or force applications.

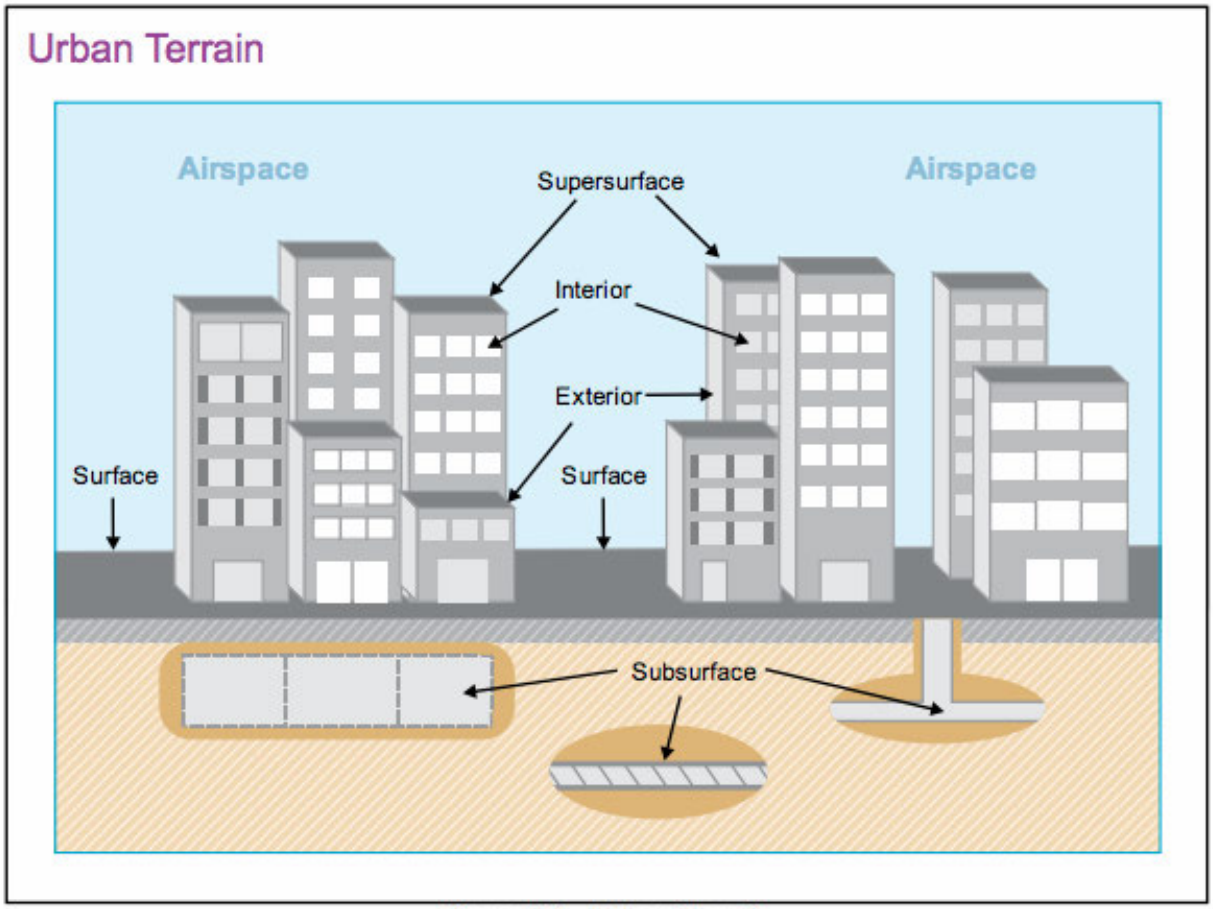


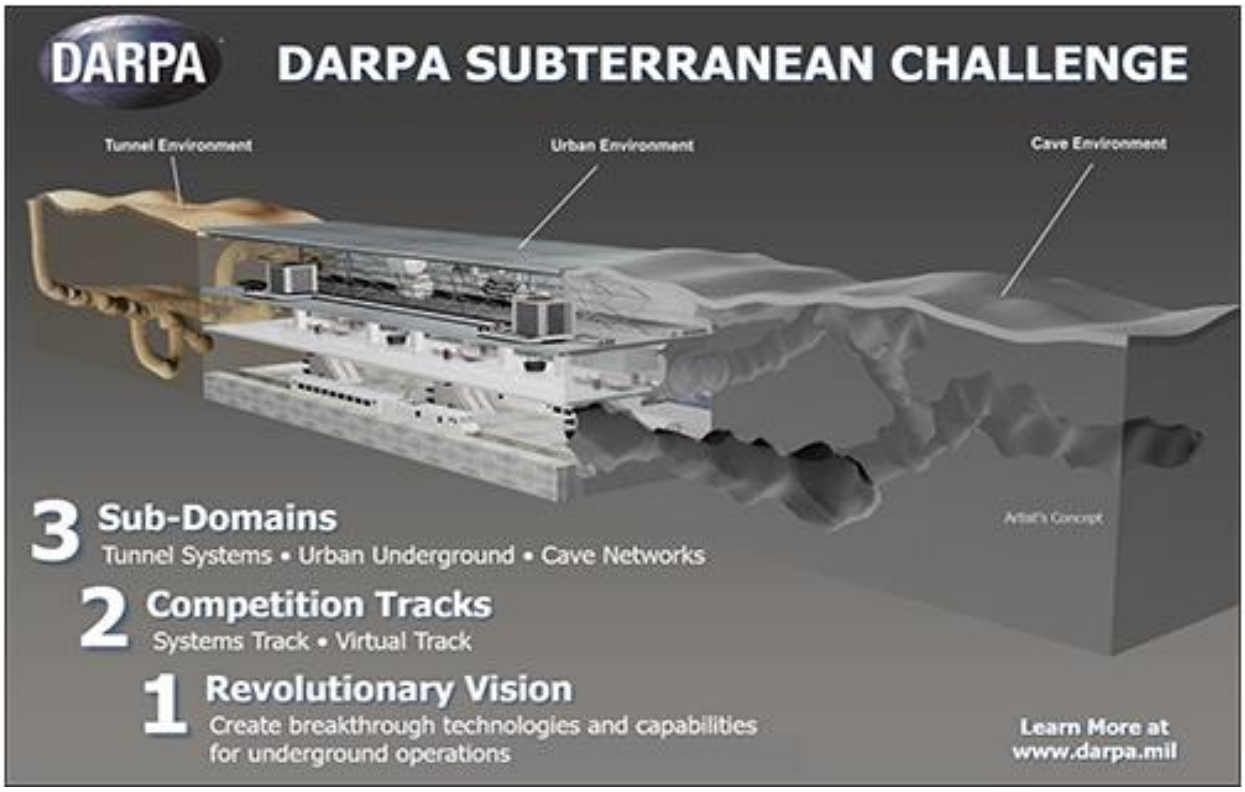
Figure II-1. Urban Terrain

Joint Publication 3-06 Urban Operations defines subsurface areas as "areas below ground level that consist of sewer and drainage systems, subway tunnels, utility corridors, or other subterranean spaces. These areas can be used for cover and concealment, movement, and engagement, but their use requires intimate knowledge of the area." [67]

However, there are some Army units in Fort Hood as part of III Corps have been reported using former World War II tunnels designed to house the atomic bomb to prepare units and technology for future subterranean operations.[68] This preparation is unique training for the units assigned to Fort Hood and is not easily replicated for others without the facilities on current instillations. Other units around the world, specifically the IDF, are well versed in tunnel

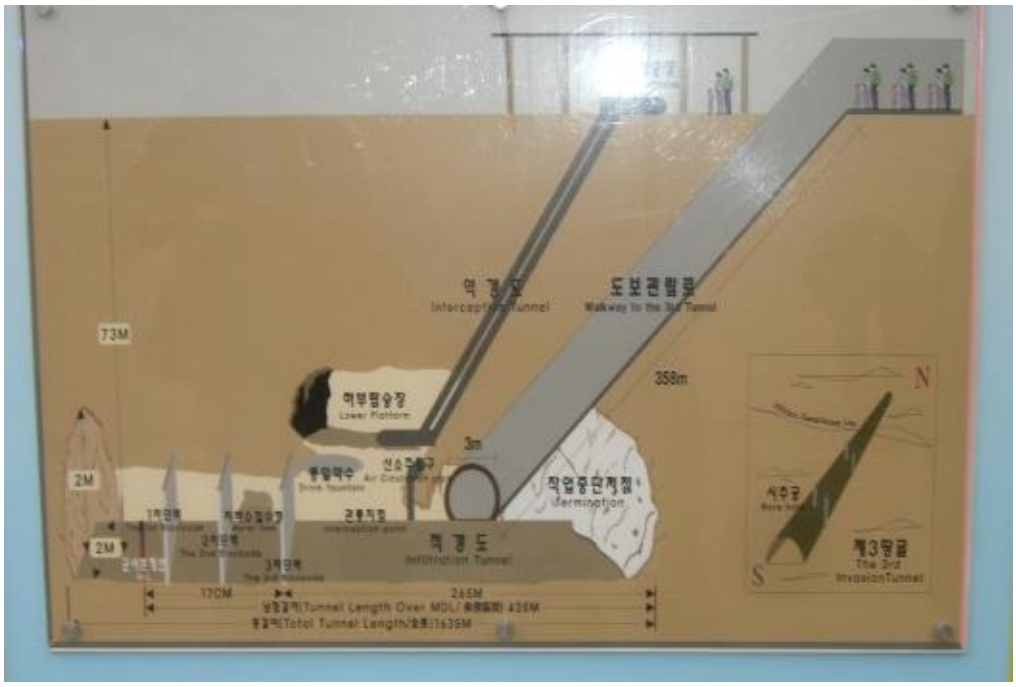
warfare and have hosted the exercise Juniper Cobra between the IDF and US European Command forces. This year 2d Battalion, 6th Marines (2/6) as the Battalion Landing Team (BLT) for the 26th Marine Expeditionary Unit (MEU) participated with the largest force since the exercise inception in 2010.[69] The BLT Commander, Lieutenant Colonel Marcus Mainz, described the tunnel warfare training as a "lost art" which would imply that US forces actually understood the challenges of dislodging an entrenched subterranean enemy, of which he is misinformed.

Lastly, to assist with applying science to the developmet of the future art of subterranean operations the military must turn to industry for leading edge technology. DARPA is home to some of the emerging technologies solicited from tech leaders in the "Subterranean Challenge Aims to Revolutionize Underground Capabilities" which was posted on December 21, 2017.[70] There is a competition of efforts to assist or outright replace humans as "tunnel rats." Many of these are built around autonomous, seismic, and laser radar (LiDAR) technology to map and sense the environment. The first phase, the tunnel phase is set to complete testing for DARPA and self funded applicants in 12 months and the entire project is set to complete testing by 2021. With the increased saber rattling on the Korean Peninsula, the testing hopefully will be complete and integrated into the force in time for a great power war.



In conclusion, tunnels with a determined enemy pose a vexing problem for the U.S. military, which lacks reliable technology to detect and map the subterranean pathways. They'll make small-unit operations extremely difficult and large-scale operations extremely slow and manpower intensive. Technology can help close the gap using speed as security to generate tempo in offensive operations. The JINSA study describes the advent of "tunnel detection and destruction technology capable of reaching significant depths in a variety of terrain conditions must be rapidly developed to counter the increased use of tunnels."[71] US Forces understand at least partially the threat posed and Congress included $40 million in its 2016 spending bill to fund anti-tunnel technology, and joint effort between the U.S. and Israel.[72]

Additionally this funding will be necessary to provide for the massive networks that most likely exist north of the Demilitarized Zone (DMZ) on the Korean Peninsula. The tunnel networks are not new, with 4 discovered tunnels at the DMZ open to the public for tours, of which Weapons Company 3d Battalion, 7th Marines toured during Exercise FOAL EAGLE in February 2008. However, there are reportedly at least 20 infiltration tunnels alone according to a former intelligence officer stationed in South Korea, not to mention the underground facilities that house artillery, command and control nodes, ballistic missiles, and possibly nuclear facilities.[73] The remote possibility of a nuclear weapon disappearing into the black market from a failed state like North Korea if hostilities erupted will drive US, South Korean, and other world partners deep into the subterranean environment to ensure that destructive capability does not fall into the wrong hands. This will most likely not be accomplished by the forces already postured in South Korea that will receive the brunt of the offensive most likely immediately conduct a counter attack. Specialty forces and equipment will have to be introduced into theater at a later date and time after the start of hostilities.



In conclusion, the solution as I propose would be to establish a force at the Army Brigade level within III Corps that is responsible for the manning, training, organizing, equipping, and integrating emerging technology as a follow on element to front line forces. The follow on forces could come from a predominately light infantry force crafted out of the III Corps in Fort Hood, most likely the heavily armored 1st Calvary Division. The reasoning is simply access to training facilities aboard Fort Hood, Texas and the access to troop formations that can dedicate training plans to counter the manpower and time intensive requirements of searching underground networks while integrating with armored formations that are most likely to bypass the obstacles presented in subterranean environments.

The 1st Calvary Division would be the premier unit around the world prepared to partner every two years with the IDF ran Juniper Cobra and integrate the lessons learned through out not only the Army, but Marine, and Coalition partners. While this is the most likely home for the innovating efforts it is a hard sell to trade tanks and armored maneuver for the dark, damp, and dimly lit underground maze of danger and defenders. Most likely, we will continue to look at history to inform industry to give the future "tunnel rat" an advantage when adversaries try to nullify the fire support and aviation advantages US forces enjoy.

The alternative Marine Corps specific conclusion is less clear. Without forces specifically assigned a mission to create doctrine, organization, training, equipping, and

employment like a full time Army Brigade, the Marine Corps will have to simulate and test as part of the Marine Corps Warfighting Laboratory (MCWL) with heavy student involvement from Marine Corps University. There are already partnerships established within DARPA and MCWL that can be leveraged so the academic year shuffle of professional military education does not take a years work with it back out to the fleet every summer. However, there should be a standing committee and dedicated uniformed faculty members within Marine Corps University that champion the learning across disciplines to ensure the work being done by scientists fits the requirements or threat updates that an evolving Marine faces each year. A new set of minds attacking a problem that will inevitably test combat formations in future conflict will bring new rigor and perspective to counter the subterranean threat that fire support dominance has gifted ground forces.

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